EXHIBIT 6

Exhibits to the Declaration of Nathan Curtis in Support of Defendants' Claim Construction Brief

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

FRACTUS, S.A., Plaintiff, v.	JURY TRIAL DEMANDED
AT&T MOBILITY LLC, Defendant.	Case No. 2:18-cv-00135-JRG LEAD CASE
SPRINT COMMUNICATIONS COMPANY, L.P., ET AL., Defendants.	Case No. 2:18-cv-00136-JRG
T-MOBILE US, INC. ET AL., Defendants.	Case No. 2:18-cv-00137-JRG
VERIZON COMMUNICATIONS INC. ET AL., Defendants.	Case No. 2:18-cv-00138-JRG
COMMSCOPE TECHNOLOGIES LLC, Defendant-Intervenor.	
CELLMAX TECHNOLOGIES AB Defendant-Intervenor.	

DECLARATION OF DR. MOHAMMOD ALI

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I. BACKGROUND

1. I have been retained as a technical expert to provide my independent opinions regarding certain technologies at issue in this case. My opinions and the basis and reasons for them are set forth in this declaration.[1]

2. I am being compensated for my time spent working on this case at a rate of $185 per hour, which is my standard consulting rate, plus reimbursement of expenses. I do not have a financial interest in the outcome of this matter.

3. I have been asked to give my opinions on certain technological issues pertaining to the following patents: U.S. Pat. Nos. 6,937,191 ("the '191 patent"); 7,250,918 (the '918 patent"); 7,557,768 ("the '768 patent"); 7,932,870 ("the '870 patent"); 8,228,256 ("the '256 patent"); 8,896,493 ("the '493 patent"); and 9,905,940 ('the '940 patent"). Each of the above patents are from a patent family entitled, "Interlaced Multiband Antenna Arrays," which I may abbreviate as "IMAA."

II. QUALIFICATIONS AND EXPERIENCE

4. I am currently a Professor in the Department of Electrical Engineering at the College of Engineering and Computing at the University of South Carolina ("USC").

5. I received my Bachelor of Science degree in electrical and electronic engineering from the Bangladesh University of Engineering and Technology, Dhaka in 1987. I received a Masters degree in 1994, and a Ph.D in 1997, both in electrical engineering from the University of

[1] To the best of my knowledge, recollection, and understanding, these are my opinions at this time based on the materials and information I have been provided and gathered and evaluated. I may supplement my opinions on a given topic in the future if new materials or information become available, including any expert declaration submitted on behalf of Fractus.

Victoria in Canada. I then worked as a postdoctoral fellow at the University of Victoria from May 1997 to December 1997.

6. Subsequent to my postdoctoral research I worked at Ericsson Inc. in North Carolina first as a Staff Engineer, and then as a Senior Staff Engineer, from January of 1998 until August of 2001. My work at Ericsson included the design, analysis, development, and testing of cellular, Bluetooth, and satellite phone antennas. In 2001, I joined the Department of Electrical Engineering at the University of South Carolina. During my tenure at the University of South Carolina, I have served as a Visiting Research Scientist with Motorola Corporation as well as a Summer Faculty Fellow at the Air Force Research Laboratory.

7. In 2003 I received the National Science Foundation Faculty Career Award and have received several additional awards from the University of South Carolina. While at USC, my research over the years has focused on several main theme areas: (1) antenna design for portable and wearable wireless communications, beam steering antennas, circularly polarized antennas and antenna miniaturization, (2) Electromagnetic Bandgap (EBG) structures and their design, (3) EBG design for isolation improvement between antennas, (4) conformal antenna design for aerospace applications including MEMS and varactor diode reconfigurable antennas, and arrays of reconfigurable antennas, (5) SAR and threshold power assessment for antennas (such as dipoles, monopoles, patches, PIFAs, etc.) at distances between 5 to 25 mm from the human head or body within the frequency range of 300 MHz to 6000 MHz; SAR and threshold power assessment for antennas and arrays (dipole arrays and microstrip patch arrays) at distances between 25 to 200 mm from the human head or body within the frequency range of 900 MHz to 6000 MHz; (6) wireless power transfer to sensors embedded in concrete using near and far field techniques, and (7) wireless sensor (Interdigital Capacitor sensor and surface wave sensor) design for infrastructure health monitoring. These research works have been sponsored through grants and contracts from the National Science Foundation, the Air Force Research Laboratory, the Army Research Office,

the Office of Naval Research, the Department of Energy, the Mobile Manufacturer's Forum (MMF), the GSM Association (GSMA), and The Boeing Company.

8. I have published extensively, having authored or coauthored over 160 technical publications, predominantly focused on antennas. I discuss some of these publications in more detail in this declaration. In addition to publishing, I was the Technical program Co-Chair of the IEEE Antennas and Propagation Society's International Symposium in Charleston, SC in 2009. I was also an Associate Editor for the journal IEEE Antennas and Wireless Propagation Letters from 2008-2013. I serve on the Technical Program Committee of the IEEE Antennas and Propagation Society's (APS) International Symposium, and have organized special session for the IEEE IWAT conference and the IEEE APS Symposium. I have also served on the Technical Program Committee of the European Association for Antennas and Propagation Conference (EUCAP).

9. I hold 8 U.S. patents, five of which focused on different aspects of antennas.

10. During my tenure at the University of South Carolina, I have taught a number of courses which include: Electromagnetics; Electronics; RF Circuit Design for Wireless; Antennas and Radiation; Microwave Devices and Circuits and Industrial, Scientific, and Medical Applications of Microwaves. For example, in the Spring of 2019 I am teaching two courses: RF Circuit Design for Wireless; Antennas and Radiation.

11. A copy of my CV is attached to this declaration.

III. MATERIALS CONSIDERED

12. In addition to my experience in this field as summarized above, and set forth in further detail in my CV, the materials that I reviewed in forming the opinions set forth in this declaration include the IMAA Patents, the relevant extrinsic evidence produced by Defendants and by Fractus, and the references cited in this declaration.

IV. PERSON OF ORDINARY SKILL IN THE ART

13. I understand that the IMAA Patents claim priority to a patent application filed on October 26, 1999. I have also been informed that Fractus alleges that it is entitled to an earlier priority date of July 1998 for certain claims. I have not yet formed any opinions as to whether Fractus is in fact entitled to a priority date of July 1998 for any of its patent claims, but regardless of whether the claims are viewed from the perspective of July 1998 or October 1999, my opinions in this declaration are not affected.

14. In my opinion, a person of ordinary skill in the art around October 1999 would have possessed a Master's Degree in Electrical Engineering, or a Bachelor's Degree in Electrical Engineering with 2-3 years of experience with antennas.

15. I was a person of at least ordinary skill in the art under this definition when the IMAA Patents were first filed, and I have routinely worked with persons of ordinary skill in the art in the course of my employment at the University of South Carolina and in my industry experience.

V. APPLIED LEGAL STANDARDS

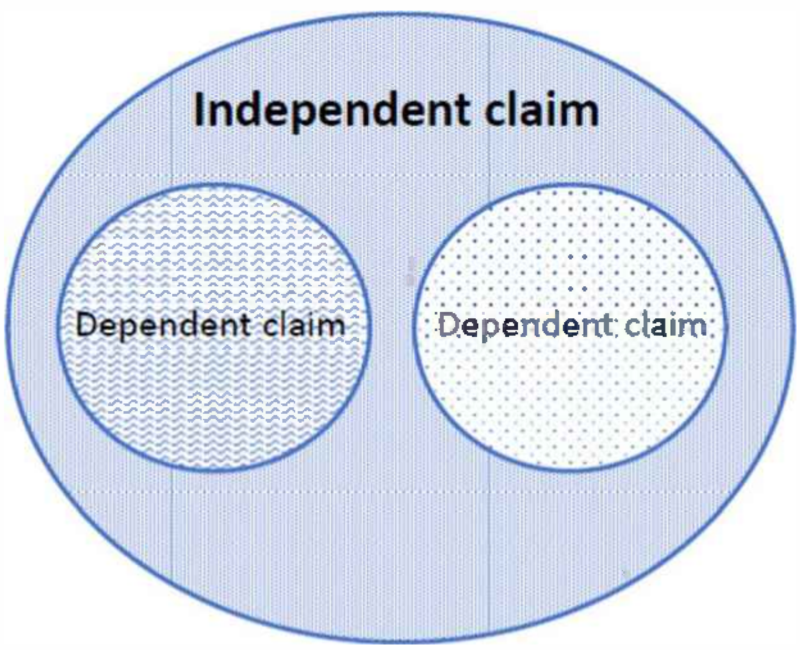
16. I am not a lawyer or legal expert, and I am not offering any opinions regarding the law. I have, however, been informed by counsel of the legal standards applicable to the issues that I have been asked to examine.

A. Claim Construction

17. I have been informed by counsel that there are two types of claims: independent claims and dependent claims. I have been informed that an independent claim stands alone and includes only the limitations it recites. I have been informed that a dependent claim, on the other hand, is a claim that depends on another claim. I have been informed that dependent claims include all of the limitations stated in the dependent claim as well as any limitations included in the

corresponding independent claim. To take one particular example, claim 1 of the '918 patent is an independent claim. Claims 12 and 13 of the '918 patent are each referred to as dependent claims. I understand that claim 12 should be read to collectively include all of the limitations present in claim 1 and in claim 12. I understand that claim 13 should be read to collectively include all of the limitations present in claim 1 and claim 13. However, I understand that claim 13 should not be read to include the limitations present in claim 12.

18. In this sense, I have been informed the relationship between an independent claim and its dependent claims can be thought of using a Venn diagram. As shown in the exemplary illustration below, an independent claim defines the outer boundary of the Venn diagram and the one or more dependent claims are defined by separate circles within the outer boundary of the independent claim.



19. I have been informed that it is the role of the Court to determine the meaning of language of the claims. I further understand that the construction of the language of the claims is

performed by viewing that language from the perspective of one of ordinary skill in the art as of the priority date of each patent.

20. I have been informed that, to properly understand the meaning of claim terms, one should consider the claim language itself in view of the patent specification (including the figures). For example, the patent specification may show that the inventor used words or terms in a manner inconsistent with their plain and ordinary meaning.

21. I have been informed that language in a dependent claim may shed some light on the meaning of the terms in the claim from which it depends. I have been informed that one generally should not interpret a claim in a way that renders the dependent claim "superfluous." In other words, one should assume that the dependent claim is necessarily narrower than the claim from which it depends.

22. I also have been informed that the prosecution history of the patent may also provide guidance in construing a claim term. For example, the prosecution history may show that the patent applicant might have limited the scope of the claims. None of my opinions in this declaration, however, are affected by the prosecution history of the IMAA Patents.

23. I have been informed that if the intrinsic evidence is not conclusive regarding the meaning of a particular claim term, extrinsic evidence may also be used to determine its meaning. I understand that extrinsic evidence may be used, for example, to help determine what a person of ordinary skill in the art at the time of the invention would understand the claim term to mean. Extrinsic evidence may include, for example, dictionaries, technical treatises, journals, articles, or expert testimony. While I understand that reliance on extrinsic evidence may be permitted in certain cases, none of my opinions in this declaration are affected by the extrinsic evidence I have reviewed.

B. Presumption of Validity

24. I have been informed by counsel that a patent claim is presumed valid, and that a challenger must establish invalidity by "clear and convincing evidence." I have been further informed and understand that, to prove an assertion by "clear and convincing evidence," the party with the burden of proof must demonstrate that it is highly probable that the assertion is true.

C. Indefiniteness

25. I have been informed that, in order to be valid, the claims of a patent must be sufficiently definite that one skilled in the art can determine the bounds of the claimed invention. I have been informed that a patent claim is deemed "indefinite" if the claim, read in light of the patent's specification and prosecution history, fail to inform, with reasonable certainty, those skilled in the art about the scope of the invention. I understand that a patent claim must be precise enough to afford clear notice of what is claimed, thereby apprising the public of what is still open to them.

VI. RELEVANT BACKGROUND OF ANTENNA TECHNOLOGY

26. Based on my knowledge and experience with these technologies, and after reviewing the documentation discussed above, I have provided an explanation of several concepts underlying the IMAA Patents that are relevant to my analyses below. Each of the concepts I discuss in the subsections below would have been well-known to a person of skill in the art in the 1998-1999 timeframe.

27. Wireless cellular communications, light wave communication, AM (Amplitude Modulation) radio, FM (Frequency Modulation) radio, GPS (the Global Positioning System), Wi-Fi, television broadcasting, etc. all use electromagnetic (EM) waves. One of many components of a wireless-communication system is an antenna, which can be used to radiate EM waves and to

receive EM waves. EM waves can be characterized by: its velocity of propagation (v); its frequency (f); and its wavelength (λ).

28. Wavelength (λ) refers to the distance between peaks of a wave, and values for wavelength are typically reported in units of meters, centimeters, or millimeters. Frequency refers to the number of times over which a wave will pass a given point in one second. As stated another way, frequency is the number of complete cycles the wave completes in one second (i.e., how fast it is). Values for frequency are typically reported in units of hertz (Hz), megahertz (MHz), and gigahertz (GHz). The velocity of propagation in free space is the speed of light, which is denoted by the letter "c" and is thus a constant. The speed of light is 3×10^8 meters/second.

29. There is a direct relationship between frequency (f) and wavelength (λ), which is shown in the equations below.

$$c = f \times \lambda \qquad \text{or} \qquad \lambda = c / f$$

As can be seen in the above equations, the frequency of an EM wave and its wavelength have a reciprocal relationship. Thus, as the frequency increases, the wavelength will decrease, and vice versa.

30. The IMAA Patents refer to the term "wavelength" in various places, e.g. "a half-wavelength" and "one wavelength."[2] Below are some frequencies and their wavelengths calculated using the above formulas:

Frequency (f)	Wavelength (λ)	½ Wavelength (0.5 λ)
890 MHz	337.1 mm	168.6 mm
960 MHz	312.5 mm	156.3 mm
1710 MHz	175.4 mm	87.7 mm
1880 MHz	159.6 mm	79.8 mm

[2] '191 patent at column 4, line 31.

VII. OPINIONS REGARDING CERTAIN CLAIM TERMS

A. "radiation and impedance patterns that are similar" or "substantially similar"

31. It is my opinion that the scope of the following claim limitations in the IMAA Patents is not reasonably certain to a person of ordinary skill in the art:

Term	Claims
"radiation and impedance patterns that are similar in a plurality of the plurality of working frequency bands"	'768, cls. 1, 9, 16, 23, 30, 38
"radiation and impedance patterns that are substantially similar in a plurality of the plurality of working frequency bands"	'870, cls. 1, 11, 20, 29

32. It is not reasonably certain to a person of ordinary skill in the art (1) what an "impedance pattern" is, or (2) what it means for either a "radiation and impedance pattern" to be "similar" or "substantially similar" to another "radiation and impedance pattern" in the context of these patents. These limitations are not defined or described in the specification of the IMAA Patents and are not otherwise understandable with reasonable certainty to a person of ordinary skill in the art.

1. The scope of the term "impedance pattern" is not reasonably certain

33. The "impedance" of an antenna is "the ratio of the voltage to current at a pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point" that is expressed as a complex quantity that includes a real part and may contain an imaginary part.[3] It is often expressed as the quantity $Z_A = R_A + jX_A$, where R_A is resistance, and X_A is reactance.

34. While the concept of the "impedance" of an antenna is understood, the term "impedance pattern," to my knowledge, did not have a well-understood meaning in the art at the time the IMAA Patents were filed. In fact, I am not personally familiar with anything referred to

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[3] A. Balanis, ANTENNA THEORY at 73 (2d ed. 1997) ("Balanis").

as an "impedance pattern" in the antenna art at any time, either at the time of the IMAA Patents or now.

35. There is no definition of "impedance pattern" in the IMAA Patents, nor are there any examples of impedance patterns described in the text or shown in the figures. The specification of the IMAA Patents repeats the term, but does not provide any examples or clarity on the meaning of "impedance pattern."[4] Furthermore, given that "impedance pattern" is not a known term to one of ordinary skill in the art, it is not clear what the IMAA Patents mean for "impedance patterns" to be "similar" or "substantially similar."

2. The scope of the term "radiation and impedance patterns that are similar" or "substantially similar" is not reasonably certain

36. A "radiation pattern" is "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and is represented as a function of the directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase or polarization."[5] The *IEEE Standard Definitions of Terms for Antennas* (IEEE Std 145-1993) ("IEEE Antenna Dictionary") similarly defines "radiation pattern" as "[t]he spatial distribution of a quantity that characterizes the electromagnetic field generated by an antenna." In other words, a radiation pattern is a numerical or graphical representation of a specific property of the radiated electromagnetic fields.

37. A radiation pattern is generally represented graphically as a function of spherical angular coordinates, Θ (theta) and Φ (phi). For example, a radiation pattern may include normalized electric field, field intensity, directivity, gain, realized gain (which includes the mismatch effects between the antenna and the feed transmission line), etc. It may also include one

[4] '191 patent at column 2, lines 19-23 and 33-39; column 5, lines 39-35.

[5] Balanis at 28.

or both polarization components (E_θ, E_ϕ components, etc.) of the gain, fields, and directivity. Radiation patterns can be plotted in three dimensions. However, three-dimensional plots of radiation patterns may not reveal all the important features of the pattern. Thus, in general, two-dimensional (2-D) radiation patterns can be plotted in some major planes. For example, one may generate a 2-D polar radiation pattern by fixing one of the spherical angles (e.g., phi) and varying the other (e.g., theta) or vice versa. Note that the angle theta varies from 0 to 180 degrees, and the angle phi varies from 0 to 360 degrees. For an antenna, one may plot a radiation pattern by keeping phi=0 degrees or phi=90 degrees and varying theta. Alternatively, one may plot a radiation pattern by keeping theta=90 degrees and varying phi. Granted that numerous other 2-D plots of radiation patterns can be created in the same manner as needed.

38. The diagrams below are examples of radiation patterns from one of my publications.[6] An excerpt from Figure 16 below shows several normalized gain patterns in the E-plane (elevation plane) at various frequencies.

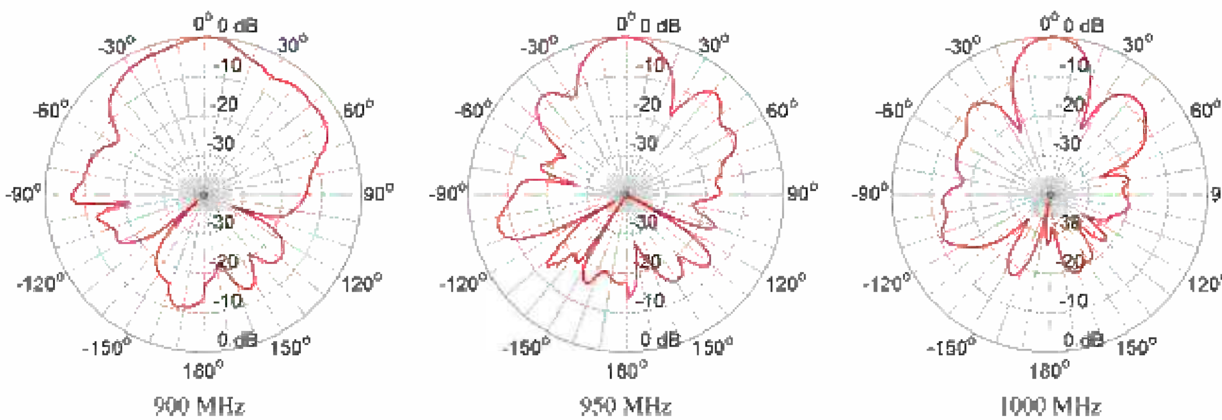

Figure 16. Measured normalized E-plane radiation patterns.

39. Various parts of a radiation pattern are referred to as *lobes*. In general, a radiation lobe is a "portion of the radiation pattern bounded by regions of relatively weak radiation

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[6] N. H. Chamok et al., *Ultrathin UHF Broadband Antenna on a Nonuniform Aperiodic Metasurface*, IEEE Antennas and Propagation Magazine, Vol. 57, No. 2 (Apr. 2015).

intensity."[7] Lobes can be subclassified into *main* (or *major*), *minor*, *side*, and *back* lobes, as shown below.[8]

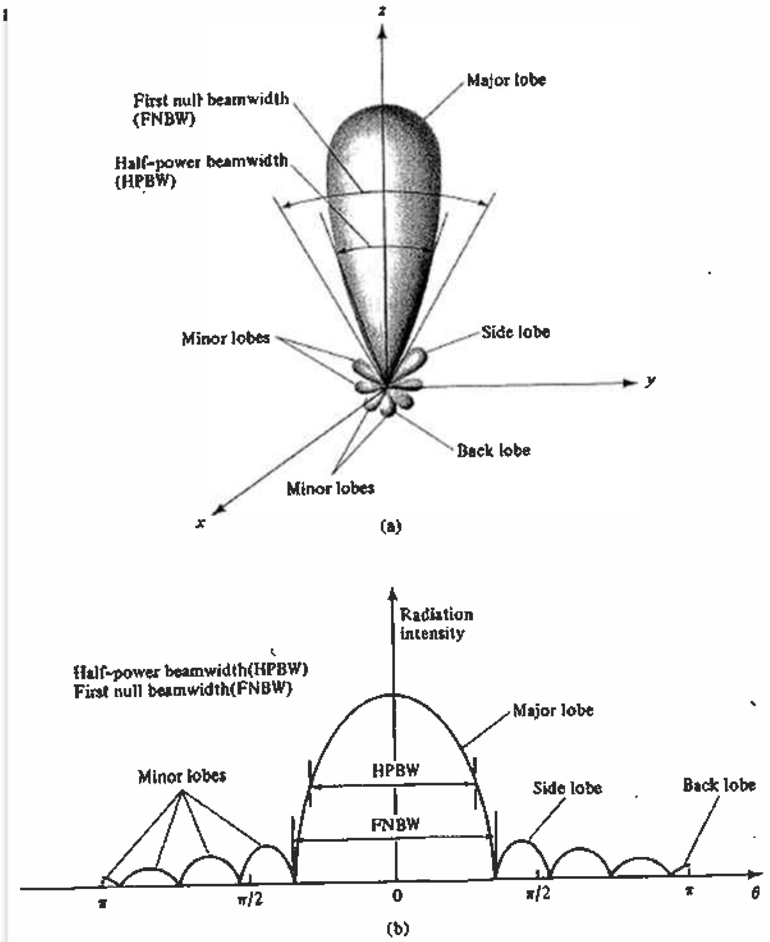

Figure 2.4 (a) Radiation lobes and beamwidths of an antenna pattern. (b) Linear plot of power pattern and its associated lobes and beamwidths.

40. A "radiation pattern" is not the same thing in all contexts. Many different quantities can be plotted to characterize radiation, including "power flux density, radiation intensity, directivity, phase, polarization, and field strength."[9] For a base station antenna, a radiation pattern

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[7] Balanis at 31.

[8] Balanis at 31.

[9] IEEE Antenna Dictionary (Std 145-1993) at 28; Balanis at 28 ("In most cases, the radiation pattern is determined in the far-field region and is represented as a function of the directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase or polarization.").

could plot any or all of these quantities. When discussing radiation patterns in the art, the specific details of the pattern (e.g., the quantities plotted, coordinates, normalization, plane of analysis, polarization, etc.) must be specified or readily ascertainable from the pattern shown.

41. It would not be reasonably clear to a person of ordinary skill in the art how to determine whether, in the context of these patents, radiation patterns are "similar" or, as stated in some claims, "substantially similar." While the concept of a radiation pattern would have been generally known to a person of ordinary skill in the art at the time of the IMAA Patents, as described above, there was no established understanding—and the IMAA Patents provide no guidance—as to what made two radiation patterns "similar" or "substantially similar." An assessment of whether two patterns are "similar" or "substantially similar" would require additional guidance to a person of skill in the art about what qualities or values of the patterns should be assessed when determining similarity, as well as guidance regarding what level of differences can be tolerated.

42. Not a single radiation pattern is depicted in the IMAA Patents. The specification of the IMAA Patents provides no guidance that would allow a person of skill in the art to know what kind of radiation patterns should be compared—e.g., patterns based on the gain, directivity, field intensity, or polarization of the radiation. Indeed, even for normalized patterns, one may need to clarify the intensity of the side lobes, the forward to backward ratio (if any), the number of side lobes, or other characteristics in order for an assessment to be attempted. The pattern comparisons could be very different depending on the quantities compared.

43. It is also unclear whether a person of ordinary skill in the art is supposed to compare just the main lobe, the main lobe and the side lobes, or all lobes. For example, two radiation patterns may have main lobes of the same size, shape, and direction, but the side and back lobes may be very different in size, shape, and direction. Again, there is no guidance in the IMAA Patents on this issue.

44. I have reproduced some figures from one of my publications that show radiation patterns with side lobes.[10] In comparing either the red or the blue radiation patterns below, the main lobes are generally in the same direction with matching widths, but the side and back lobes do not always share those characteristics. There is no guidance in the IMAA Patent specification regarding whether radiation patterns like these, given the differences in side and back lobes, would be "similar" or "substantially similar." Whether or not two radiation patterns would be considered "similar" or "substantially similar" to each other would depend on their intended applications and on the subjective assessment of the engineer comparing them. Different persons of skill in the art could have different conclusions regarding the similarity of these radiation patterns.

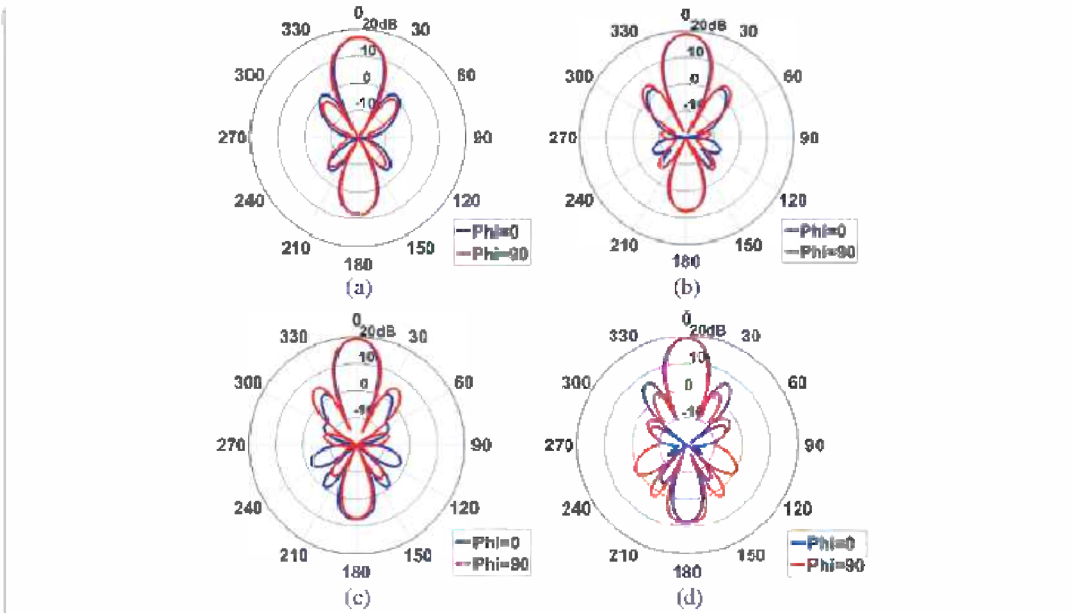

Figure 7. Simulated radiation patterns at (a) 2.45, (b) 2.65, (c) 2.85, and (d) 3.05 GHz.

45. Consider two broad possible categories of radiation patterns: *directional*, and *omnidirectional* patterns. A *directional* antenna (according to the *IEEE Standard Definitions of Terms for Antennas* (IEEE Std 145-1993)) is one "having the property of radiating or receiving

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[10] D. Poduval et al., *Wideband Aperture Coupled Patch Array Antennas – High Gain, Low Side Lobe Design*, Progress in Electromagnetics Research, Vol. 160, 71–87 (2017).

electromagnetic waves more effectively in some directions than others." Note the term "some direction(s)," which implies there could be more than one direction. An *omnidirectional* antenna (according to the *IEEE Standard Definitions of Terms for Antennas* (IEEE Std 145-1993)) is one "having an essentially nondirectional pattern in a given plane of the antenna and a directional pattern in any orthogonal plane." Just because two radiation patterns are both "directional," or two radiation patterns are both "omnidirectional," that does not mean that a person of ordinary skill in the art would understand the two patterns to be "similar." For example, even if two radiation patterns are directional (like those above), there may be different horizontal or vertical half-power beam widths, and the side lobe levels with respect to the main lobe may differ. One pattern may have more cross-polarization than the other. Again, there is no guidance in the specification of the IMAA Patents regarding whether radiation patterns with such differences are still "similar." It is unclear what differences in which radiation pattern characteristics (e.g., half power beamwidth, forward-to-backward ratio, beam shape, number of lobes, lobe direction, side lobe level with respect to the main lobe, vertical polarization, horizontal polarization, gain, etc.) would be used to assess the similarity of two patterns. Depending on the application and on the views of a given antenna engineer, some or all of these factors may be important for determining what levels of differences are tolerable while remaining "similar."

46. As mentioned above, some of the claims require radiation and impedance patterns to be "similar" (e.g., the claims of the '918 patent), while others require them to be "substantially similar" (e.g., the claims of the '870 patent). There is no guidance in the specification about the difference between "similar" and "substantially similar" impedance patterns. At what point do two radiation patterns go from being "substantially similar" to simply "similar"? A person of ordinary skill in the art would not have any certainty regarding this subjective assessment, and the patents themselves provide no guidance.

B. "situated around" terms

47. I have been asked to analyze whether the term "situated around," when used in the claims below, provides reasonable certainty to a person of ordinary skill in the art. It is my opinion that the terms below that use the phrase "situated around" do not inform, with reasonable certainty, those of ordinary skill in the art about the scope of the alleged invention.

Term	Claims
"the working frequency bands are situated around 900 MHz and 1800 MHz"	'918, cl. 12
"the working frequency bands are situated around 900 MHz, 1800 MHz, and 2100 MHz"	'918, cl. 14
"the working frequency bands are situated around 800 MHz and 1900 MHz"	'918, cl. 15
"the working frequency bands are situated around 800 MHz, 1900 MHz, and 2100 MHz"	'918, cl. 19
"at least one of the working frequency bands is situated around 1900 MHz"	'918, cl. 24
"two working frequency bands of the plurality of working frequency bands are situated around 900 MHz and 1800 MHz"	'768, cls. 3, 24, 33, 39
"three working frequency bands of the plurality of working frequency bands are situated around 900 MHz, 1800 MHz, and 2100 MHz"	'768, cls. 5, 35, 41 '870, cls. 8, 17, 36
"two working frequency bands of the plurality of working frequency bands are situated around 800 MHz and 1900 MHz"	'768, cls. 6, 27, 36, 42 '870, cls. 9, 27, 37
"at least one of the plurality of working frequency bands is situated around 1900 MHz"	'768, cl. 13 '870, cl. 25
"at least one of the plurality of working frequency bands of the interlaced multiband antenna array is an operating band situated around 2100 MHz"	'768, cl. 16
"two working frequency bands of the plurality of working frequency bands are situated around 1900 MHz and 3500 MHz"	'768, cl. 25
"three working frequency bands of the plurality of working frequency bands are situated around 900 MHz, 1800 MHz, and 2100 MHz"	'768, cls. 26
"two working frequency bands of the plurality of working frequency bands are situated around 1800 MHz and 2100 MHz"	'870, cl. 3
"two working frequency bands of the plurality of working frequency bands are situated around 1900 MHz and 2100 MHz"	'870, cls. 7, 16, 35

Term	Claims
"the first working frequency band is situated around 1800 MHz and wherein the second working frequency band is situated around 2100 MHz"	'870, cl. 13
"three working frequency bands of the plurality of working frequency bands are situated around 1800 MHz, 1900 MHz, and 2100 MHz"	'870, cls. 18, 22
"an operating frequency of the first continuous frequency range is situated around 900 MHz and an operating frequency of the second continuous frequency range is situated around 1800 MHz"	'493, cl. 1

48. The phrase "situated around" has no special usage in the field of antennas to my knowledge, and each person of ordinary skill in the art may have a different understanding as to whether a particular range of frequencies is "situated around" another frequency. The specification of the IMAA Patents also does not clarify the bounds of this term, and a person of ordinary skill in the art would not be able to reasonably determine the scope of these claim terms.

49. As a starting point, the IMAA Patents do not define or explain the term "situated around." In fact, this term is not even used in the patents outside of the claims. There are also no figures in the IMAA Patents that specifically illustrate or otherwise provide insight or an explanation into the boundaries of the term "situated around."

50. The term "situated around" is one of degree that, in the context of the limitations listed above, relates to how near (or "around") the claimed frequency band must be to the claimed frequency. For instance, claim 12 of the '918 patent states that "the working frequency bands are situated around 900MHz and 1800MHz." However, none of the IMAA Patents provide a specific explanation as to how "around" the working frequency bands must be to 900MHz and 1800MHz. Without such an explanation, it is not possible to determine what would fall within the bounds of "around" and what would not. Again, the specification of the IMAA Patents provides no explanation or figures that illustrate how to apply this concept. There are also no algorithms or other methodologies disclosed in the IMAA Patents that specifically explain how "around" the

"working frequency bands" must be to 900MHz and 1800MHz, including how any such determination could be quantified or measured.

51. The lack of clarity in the language in the claims listed above can be compared to the language appearing in, for instance, claim 12 of the '191 patent which provides that "the working frequency bands are *situated around* 900 MHz and 1800 MHz *in order to provide service simultaneously for the GSM 900 and GSM 1800 cellular mobile telephony systems.*" Unlike this claim language, the claims listed above do not identify the systems in which the frequencies are used, and do not provide further clarity as to any objective bounds to measure "situated around."

52. The IMAA Patents also explain that the GSM 900 system correlates with frequencies from 890-960 MHz and that the GSM 1800 system correlates with frequencies from 1710-1880 MHz.[11] These include numerous frequencies therein, but nowhere does any asserted patent indicate that a frequency band is "situated around" a particular frequency if that frequency simply happens to be included anywhere within the larger band (including frequencies at the tail of that band). For example, the patent does not describe or state that a frequency range of 890-960 MHz (used for the GSM 900 system) is "situated around" either of 890 MHz or 960 MHz. A person of ordinary skill in the art would not understand the GSM 900 system to be "situated around," for example, 890 MHz or 960 MHz. To the contrary, a person of ordinary skill in the art would understand and describe such a cellular service as operating between 890 MHz to 960 MHz and having a center frequency of 925 MHz ((890 MHz + 960 MHz)/2).

C. "substantially arranged"

53. It is my opinion that the scope of the following claim limitations are not reasonably certain to a person of ordinary skill in the art:

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[11] '191 patent at column 7 lines 33-38.

Term	Claims
"the first plurality and the second plurality of antenna elements arranged on the ground plane layer, and substantially arranged along a first direction with respect to a longitudinal axis of the interlaced multiband antenna array"	'493, cl. 1
"the first set and the second set of antenna elements arranged on the ground plane and substantially arranged along a first direction with respect to a longitudinal axis of the interlaced multiband antenna array"	'493, cl. 11
"the first plurality of antenna elements and the second plurality of antenna elements are substantially arranged along a longitudinal direction of the antenna array"	'940, cl. 8

54. There is no guidance in the specifications of the IMAA Patents to provide a person of ordinary skill in the art with reasonable certainty about the scope of what it means to be "substantially arranged" along a longitudinal axis or direction. Indeed, this term "substantially arranged" (or even the term "substantially") does not appear anywhere in the specifications. Where the specification provides examples of "arranged" elements along a straight line, those examples are of perfectly aligned linear arrays (where the exact center of each element lies on the same axis). The term "substantially arranged along a longitudinal [axis/direction]" lifts the requirement that the elements be arranged in a perfectly linear manner, and suggests undefined tolerances of *some* lateral deviation or shift from a perfectly aligned arrangement along the longitudinal axis. However, a person of ordinary skill in the art would not understand which elements should be considered "substantially" arranged along an axis and those that should not, and this would depend on the opinions of a designer and the intended application for the array.

55. By way of background, a "collinear antenna array" was a well-understood class of arrays in which the elements are mounted in parallel and collinear one to another, that is, they are aligned in a straight line.[12] Figs. 1a and1b of the IMAA Patents illustrate examples of linear arrays.

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[12] IEEE SEVENTH EDITION (2000), p. 7 ("collinear array antenna: A linear array of radiating elements, usually dipoles, with their axes lying in a straight line.").

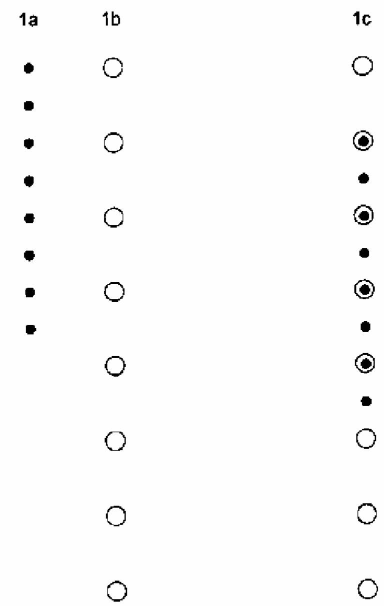

FIG. 1

56. Although the claims call for the elements to be "substantially arranged" along an axis, the elements in the figure above appear perfectly aligned. Turning to the specification's description of Figure 1 does not further clarify these terms.[13] This passage only describes the overall spacing between the elements along the longitudinal axis, but does not state how far the elements would be permitted to shift from that axis in the lateral direction while still remaining "substantially" arranged along that axis. Even in the description of the specification that "elements be repositioned, as in FIG. 5,"[14] the specification only describes how to reposition the elements along the longitudinal axis.[15] This *vertical* repositioning is illustrated in Figure 5, but all of the elements of Figure 5 appear perfectly aligned along an axis.[16]

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[13] '191 patent at column 5, lines 20-24 (explaining the spacing between elements).

[14] '191 patent at column 6, line 66 to column 7, line 2.

[15] '191 patent at column 7, lines 13-19.

[16] '191 patent at FIG. 5.

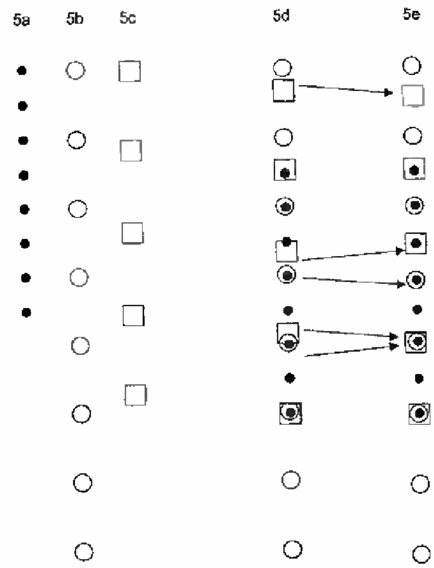

FIG. 5

57. Thus, the terms identified above would not have been reasonably clear to a person of ordinary skill in the art, and such a person would be unable to reasonably determine the boundaries of the claimed inventions.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, understanding, and recollection.

Mohd. Ali

Dr. Mohammod Ali
January 14, 2019

Mohammod Ali

I. Personal

Citizenship – United States of America
Marital Status – Married with two children

II. Academic Preparation

Ph.D. Electrical Engineering, University of Victoria, BC, Canada, 1997
M.A.Sc. Electrical Engineering, University of Victoria, BC, Canada, 1994 B.Sc. Electrical and Electronic Engineering,
Bangladesh University of Engineering and Technology, 1987

III. Professional Positions

January 2013-Present	Professor, Department of Electrical Engineering (EE), University of South Carolina (USC), Columbia
August 2007-December 2012	Associate Professor, Dept. of EE, USC, Columbia
August 2001- July 2007	Assistant Professor, Dept. of EE, USC, Columbia
March 2001–August 2001	Senior Staff Engineer, Ericsson Incorporated, Research Triangle Park, NC
January 1998 – March 2001	Staff Engineer, Ericsson Incorporated, Research Triangle Park, NC
May 1997 - December 1997	Post-Doctoral Fellow, Department of Electrical and Computer Engineering, University of Victoria, Canada
September 1992 – May 1997	Research Assistant, Department of Electrical and Computer Engineering, University of Victoria, Canada
September 1992 – May 1997	Teaching Assistant, Department of Electrical and Computer Engineering, University of Victoria, Canada
January 1988 – Sept. 1992	Lecturer, Department of Electrical and Electronic Engineering, Bangladesh Institute of Technology, Chittagong, Bangladesh

Visiting Appointments

June 2013 – June 2014	Visiting Professor, AFRL, WPAFB, Ohio (Sabbatical)
June 2011 – August 2011	AFOSR[a] Summer Faculty Fellow, AFRL[b], WPAFB[c], Ohio
June 2010 – August 2010	AFRL Summer Faculty Fellow, AFRL, WPAFB, Ohio
June 2004–August 2004	Visiting Research Scientist, Motorola Corporate EME Research Laboratory, Plantation, Florida

a. AFOSR – Air Force Office of Scientific Research
b. AFRL – Air Force Research Laboratory
c. WPAFB – Wright Patterson Air Force Base

IV. Honors, Awards, and Membership

- **National Science Foundation (NSF) Faculty Career Award**, 2003-2009.
- **Samuel Litman Distinguished Professor Award**, College of Engineering and Computing, University of South Carolina (2011).
- **Research Progress Award**, College of Engineering and Computing, University of South Carolina (2009).
- **Young Investigator Research Award**, College of Engineering and Information Technology, University of South Carolina (2006).
- **Manager's Award**, Ericsson Incorporated, Research Triangle Park, NC, 2001
- **Nominated for Governor General's Gold Medal Award** for outstanding Ph.D. research in Canada, 1998
- **Talentpool Scholarship** - Government of Bangladesh, 1981 - 1985. For Obtaining **2nd** position in the combined merit list in the Nationwide Higher Secondary Certificate Examination under Jessore Board (one of four boards in Bangladesh), 1981
- **Senior Member** of the IEEE

V. Research Interests

- **Antennas for Mobile Wireless Communications** – Multiband or wideband antenna design for mobile wireless communications for handhelds, wearables, and base stations. Frequency and pattern reconfigurability, MIMO, SAR, platform integrated antennas.
- **Reconfigurable Antennas for mm-Wave** – high performance GaN based phased array antennas for the handheld and wireless access points for 5G mm-Wave communications. This includes high data rate wireless cellular at 28 and 38 GHz and short distance device to device communications at 60, 77 GHz. Phased arrays for high resolution X-band weather radar.
- **Metamaterials and metasurfaces for Antennas and Signals** – broadband metamaterials for conformal aircraft antennas, broadband absorption materials, crosstalk reduction in printed circuit boards, Electromagnetic Interference (EMI) suppression in power converters, electromagnetic wave sink, high-intensity radiated fields (HIRF) suppression
- **Conformal Antennas in Aerospace Applications** – broadband, load bearing, reconfigurable, pixelated, phased arrays (low VHF to mm wave frequencies); broadband endfire, X, Ka, and 60 GHz phased arrays embedded in aerospace composite materials.
- **Wireless power transfer and wireless sensing in infrastructure** – near and far field wireless power transfer, wireless sensing, e.g. moisture sensor

Selected Non-Academic Collaborations and Partnerships – Air Force Research Laboratory (James Tuss, William Baron, Michelle Champion); Army Research Laboratory (Dr. Steve Weiss), Nextgen Aeronautics (Dr. Jayant Kudva), Aurora Flight Sciences Corporation (Ed Wen), Pharad Inc. (Dr. Rod Waterhouse), Motorola (Dr. Antonio Faraone), IT IS, Switzerland (Dr. Mark Douglas), Jarden Applied Materials (Gary Martek)

Grants and Contracts

[1] Title: Novel NDE Sensors, Waveforms, Models, and Algorithms for Cable Health Monitoring, RC-5: Materials Aging and Degradation Sponsor: Department of Energy NEUP
Duration: **October 1, 2017 – September 30, 2020** Amount and Role: **$800,000, Dr. M. Ali, PI**

[2] Title: Radio-Frequency of Hydride Materials
Sponsor: Savannah River National Laboratory, DOE
Duration: **September 18, 2017 – September 17, 2018** Amount and Role: **$65,000, Dr. M. Ali, PI**

[3] Title: METAMATERIALS FOR RADIO FREQUENCY INTERFERENCE (RFI) AND ELECTROMAGNETIC INTERFERENCE (EMI) REDUCTION
Sponsor: Boeing Corporation
Duration: **August 2016- October 2018** Amount and Role: **$123,000, Dr. M. Ali, PI**

[4] Title: *Reconfigurable Pixel Based Conformal Load Bearing Antenna Structures (CLAS),*
Sponsor: Air Force Research Laboratory
Duration: **January 2011- February 2019**
Amount and Role: **$686,709**, Dr. M. Ali, PI

[5] Title: *Novel Beam Steering Apertures and Waveforms for High Capacity Broadband Wireless Nodes*
Sponsor: National Science Foundation
Duration: **January 2013- December 2017**
Amount and Role: **$539,955, Dr. M. Ali, PI**; Dr. Huseyin Arslan and Dr. Akhter Ahmed Co-PI

[6] Title: *In-Situ Thermal Imaging of Manufacturing of Heterogeneous Materials and Their Multi-Physical Response*
Sponsor: Vice President for Research, USC (Internal)
Duration: 2/2013-12/2013
Amount and role - **$100,000** equipment grant, Dr. Prasun K. Majumdar, PI, Dr. M. Ali, Dr. K. Reifsnider, and Dr. T. Farouk, Co-PI.

[7] Title: *Foundations of Broadband Multifunctional Metamaterials Inspired by the Analogy of Formation*
Sponsor: US Army Research Office
Duration: **April 2012- December 2012** Amount and Role: **$49,906, Dr. M. Ali, PI**

[8] Title: *Power Electronics, Architectures, Controls, and Design Tools for Electric Ship Systems*
Sponsor: Office of Naval Research
Duration: 2008-2013
Amount and Role: $7,970,000, **Dr. Roger Dougal, PI,** Dr. H. Ginn, Dr. Y.-J. Shin, Dr. E. Santi, Dr. J. Khan, and **Dr. M. Ali, Co-PI, Ali's Share $430,000.**

[9] Title: Co*nformal Antennas for Unmanned Aircraft Systems (UAS)*
Sponsor: Air Force/Aurora Flight Sciences Corporation Phase I SBIR
Duration: **January 2011-September 2011** Amount and Role: **$30,000, Dr. M. Ali, PI.**

[10] Title: *Reconfigurable Load Bearing Pixel Antenna Structures*
Sponsor: Air Force Office of Scientific Research (AFOSR)
Duration: June-August 2011
Amount and Role: **$25,000 of summer support for self and grad student, Dr. M. Ali, PI.**

[11] Title: *Novel Wireless Powered Embedded Sensors for Structural Health Monitoring*
Sponsor: NSF Phase I SBIR through Advanced Flex Sensor Research*
(*I formed this company in 2009; the project PI was Dr. Rashed Bhuiyan my former PhD student)
Duration: **January–July 2011**
Amount and Role: **$10,440** for USC out of $140,841, **Dr. M. Ali, Co-PI.**

[12] Title: *Research on Wide Band Low Profile Antennas using Electromagnetic Bandgap Metamaterials*
Sponsor: Air Force Research Laboratory
Duration: **June 2010 – January 2011**
Amount and Role: **$25,170, of summer support for self, Dr. M. Ali, PI.**

[13] Title: *Flexible, Ultra-Thin, Packaged Antennas and Arrays for Next Generation Wireless Applications*
Sponsor: NSF Career Award
Duration: **2003 – 2009** Amount and Role: **$412,000, Dr. M. Ali, PI**

[14] Title: *Development of a Novel Wireless Sensor System Test-Bed for Infrastructure Monitoring and Biomedical Applications*
Sponsor: NSF MRI (Major Research Instrumentation)
Duration: **2006 – 2011**
Amount and Role: **$200,000, Dr. M. Ali, PI.**

[15] Title: *Low Power Exemption Rationale for Wireless Transmitters at Distances of 25 mm or greater from the User*
Sponsor: Mobile Manufacturer's Forum and GSM Association, Brussels, Belgium,
Duration: **2008 – 2010**
Amount and Role: $195,181, Dr. M. Ali, PI and DI Gernot Schmid, Seibersdorf Laboratory, Austria, Co-PI

[16] Title: *Developing a Thermal Exemptions Rationale for Low-Power Transmitters*,
Sponsor: Mobile Manufacturer's Forum and GSM Association, Brussels, Belgium,
Duration: 2008 – 2010,
Amount and Role: **$196,139, Dr. M. Ali, PI** and Dr. Revaz Zaridze, Tbilisi State University, Republic of Georgia, Co-PI

[17] Title: *Determining Maximum Allowable Emitted Power Level from Low-Power Transmitters for SAR Compliance*
Sponsor: Mobile Manufacturer's Forum and GSM Association, Brussels, Belgium,
Duration: **2005 – 2007**
Amount and Role: **$180,000, Dr. M. Ali, PI** and DI. Gernot Schmid, Seibersdorf Laboratory, Austria, Co-PI

[18] Title: C*orrelating Threshold Power and Antenna Performance* Characteristics, Sponsor: Motorola Corporate EME Research Lab, Plantation, Florida, Duration: **June-August 2004**
Amount and Role: **$25,000**, **of summer support for self, Dr. M. Ali, PI**

[19] Title: *Powered Non-Destructive Evaluation of Transportation Infrastructures using Wireless Embedded Sensors*
Sponsor: South Carolina State University Transportation Center,
Duration: **2005-2006,**
Amount and Role: **$46,258, Dr. M. Ali, PI,** Dr. Abdul Miah, Co-PI

[20] Title: *Electric Ship Research and Development* Consortium, $10,816,295
Sponsor: Office of Naval Research
Duration: **2002-2007**
Amount and Role: **$10,816,295, Dr. Roger Dougal, PI, Dr. M. Ali, and others Co-PI, Ali's Share, $385,000.**

[21] Title: *AlInGaN MOSDHFET Based RF* Circuits,
Sponsor: Missile Defense Agency
Duration: 2003-2005
Amount and Role: $1.445M, **Dr. Asif Khan, PI, Dr. M. Ali, and others Senior Personnel, Ali's Share, $144,500.**

VI. Publications

A. Refereed Journal Publications

[1] R.H. Bhuiyan, J.M. Caicedo, and M. Ali, "A Study of 13.5 MHz Coupled Loop Wireless Power Transfer under Concrete and near Metal," *IEEE Sensors Journal,* pp. 9848-9855, Dec. 2018.

[2] M.D. Wright, W. Baron, J. Miller, J. Tuss, D. Zeppettella, and Mohammod Ali, "MEMS reconfigurable broadband patch antenna for conformal applications," *IEEE Transactions on Antennas an Propagation,* vol. 66, no. 6, pp. 2770-2778, June 2018.

[3] X. Jin and M. Ali, "Simple empirical formulas to estimate the dielectric constant and conductivity of concrete," *Microwave and Optical Technology Letters*, pp. 1-5, DOI: 10.1002/mop.31577, Nov. 2018.

[4] D. Zeppettella and M. Ali, "Conformal Load-Bearing Antenna Structure for MIMO Applications," *Applied Computational Electromagnetics Society Journal*, vol. 33, no. 9, pp. 979-989, September 2018.

[5] S. Keerthi, A. Hamad, A. Mian, J. Clifford, P. Majumdar, N. Chamok, and M. Ali, "Effect of Heterogeneity in Additively Manufactured Dielectric Structures on Radio-Frequency Response of Microstrip Patch Antennas," *International Journal of RF and Microwave Computer-Aided Engineering*, DOI: 10.1002/mmce.21234, 2017.

[6] D. Poduval and M. Ali, "Wideband Aperture Coupled Patch Array Antennas - High Gain, Low Side Lobe Design," *Progress in Electromagnetics Research*, vol. 160, pp. 71-87, 2017.

[7] M.H. Yilmaz, S. Kose, N.H. Chamok, M. Ali, and H. Arslan, "Partially overlapping filtered multitone with reconfigurable antennas in uncoordinated networks," *Elsevier Journal of Physical Communication*, vol. 25, part 1, pp. 249-258, Dec. 2017.

[8] V.S.Tummala, A. Mian, N.H. Chamok, D. Poduval, M. Ali, J. Clifford, and P. Majumdar, "Three-dimensional printed dielectric substrates for radio frequency applications," *ASME Journal of Electronic Packaging*, vol. 139, 020904-1-7, June 2017.

[9] N.H. Chamok, M.H. Yilmaz, A. Arslan, and M. Ali, "High-Gain Pattern Reconfigurable MIMO Antenna Array for Wireless Handheld Terminals," *IEEE Transactions on Antennas and Propagation*, pp, 4306-4315, Oct. 2016.

[10] R.H. Bhuiyan, M.N. Alam, J.M. Caicedo, and M. Ali, "Real-Time Wireless Moisture Sensing in Materials using Planar Interdigitated Sensors," *Sensors & Transducers,* vol. 195, Issue 12, December 2015, pp. 30-38.

[11] Md. Anas B. Mazady, G. Schmid, R. Uberbacher, and M. Ali, "SAR Induced by Low and High Directivity Antenna Apertures at Distances Greater than 25 mm from the Body," *Applied Computational Electromagnetic Society (ACES) Journal*, Vol. 30, No. 9, pp. 940-951, September 2015.

[12] N.A Bishop, J. Miller, D. Zeppettella, W. Baron, J. Tuss, and M. Ali, "A Broadband HighGain Bi-Layer LPDA for UHF Applications," *IEEE Transactions on Antennas and Propagation*, pp. 2359-2364, May 2015.

[13] Y. Peng, B.M.F Rahman, T. Wang, N. Chamok, M. Ali, and G. Wang, "Engineered Smart Substrate with Embedded Patterned Permalloy Thin Film for RF Applications," *Journal of Applied Physics*, 117, 17B709 (2015).

[14] N.H. Chamok, T. Anthony, S.J. Weiss, and M. Ali, "Ultra-Thin UHF Broadband Antenna on A Non-Uniform Aperiodic Metasurface," *IEEE Antennas and Propagation Magazine*, vol. 57, pp. 167-180, April 2015.

[15] X. Jin, J.M. Caicedo, and M. Ali, "Near-Field Wireless Power Transfer to Embedded Smart Sensor Antennas in Concrete," *Applied Computational Electromagnetic Society (ACES) Journal*, 30(3):261-9, March 2015.

[16] X. Jin and M. Ali, "A Novel 3-D Cubic Loop Antenna with Nearly Isotropic Pattern," *Microwave and Optical Technology Letters*, vol. 56, pp. 1511-1513, July 2014.

[17] Md. Nazmul Alam, D. Coats, Y.-J. Shin, R. Dougal, and M. Ali, "A New Method to Estimate the Average Dielectric Constants of Aged Power Cables," *Journal of Electromagnetic Waves and Applications*, 28:7, 777-789, 2014.

[18] Md. Nazmul Alam, R.H. Bhuiyan, R. Dougal, and M. Ali, "Design and Application of Surface Wave Sensors Non-Intrusive Power Line Fault Detection," *IEEE Sensors Journal*, vol. 13, no. 1, pp. 339-347, Jan. 2013.

[19] Md. R. Islam and M. Ali, "A 900 MHz Beam Steering Parasitic Antenna Array for Body Wearable Wireless Applications," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 9, Sept. 2013, pp. 4520-4527.

[20] Md. Nazmul Alam, R. Dougal, and M. Ali, "Electrically Small Broadband VHF/UHF Planar Antenna Matched using a Non-Foster Circuit," *Microwave and Optical Technology Letters*, vol. 55, Oct. 2013, pp. 2494-2497.

[21] Md. R. Islam and M. Ali, "Temperature Rise Induced by Wire and Planar Antennas in a High-Resolution Human Head Model," *IEEE Transactions on Electromagnetic Compatibility,* vol. 55, no. 2, April 2013, pp. 288-298.

[22] G. Yang, R. Islam, R.A. Dougal, and M. Ali, "A Stacked Patch Antenna and Switched Feed Network for Wireless Power Beaming and Data Telemetry," Progress In Electromagnetics Research C, Vol. 29, 67-81, 2012.

[23] Md. R. Islam and M. Ali, "Switched Parasitic Dipole Antenna Array for High-Data-Rate Body-Worn Wireless Applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 11, pp. 693-696, 2012.

[24] Md. R. Islam and M. Ali, "Ground Current Modification of Mobile Terminal Antennas and its Effects," *IEEE Antennas and Wireless Propagation Letters,* vol. 10, pp. 438-441, 2011.

[25] Md. R. Islam and M. Ali, "Elevation Plane Beam Scanning of a Novel ESPAR Antenna for 1900 MHz Mobile Handheld Terminals," *IEEE Transactions on Antennas and Propagation,* pp. 3344-3352, Oct. 2010.

[26] Md. Nazmul Alam, R.H. Bhuiyan, R. Dougal, and M. Ali, "Concrete Moisture Content Measurement Using Interdigitated Near-Field Sensors," *IEEE Sensors Journal*, vol. 10, pp. 1243-1248, July 2010.

[27] X. Jin and M. Ali, "Embedded Antennas in Dry and Saturated Concrete for Application in Wireless Sensors," *Progress in Electromagnetic Research, PIER 102,* pp. 197-211, 2010.

[28] R.H. Bhuiyan, R. Dougal, and M. Ali, "A Miniature Energy Harvesting Device for Wireless Sensors in Electric Power Systems," *IEEE Sensors Journal,* vol. 10, pp. 12491258, July 2010.

[29] M.Z. Azad and M. Ali, “A Miniature Implanted Inverted-F Antenna for GPS Application,” *IEEE Transactions on Antennas and Propagation*, vol. 57, pp. 1854-1858, Jun 2009.

[30] A.T.M. Sayem, S. Khan, and M. Ali, “A Miniature Spiral Diversity Antenna System with High Overall Gain Coverage and Low SAR,” *IEEE Antennas and Wireless Propagation Letters*, pp. 49-52, 2009.

[31] A.T.M. Sayem, M.G. Douglas, G. Schmid, B. Petric, and M. Ali, “Correlating Threshold Power with Free-Space Bandwidth for Low Directivity Antennas,” *IEEE Transactions on Electromagnetic Compatibility*, pp. 25-37, Feb. 2009.

[32] M.Z. Azad and M. Ali, “Novel Wideband Directional Dipole Antenna on a Mushroom EBG Structure,” *IEEE Transactions on Antennas and Propagation*, pp. 1242-1250, May 2008.

[33] M. F. Abedin, M.Z. Azad, and M. Ali “WideBand Smaller Unit-Cell Planar EBG Structures and their Application,” *IEEE Transactions on Antennas and Propagation,* pp. 903-908, March 2008.

[34] M. Ali, A. T. M. Sayem and V. K. Kunda, “A Reconfigurable Stacked Microstrip Patch Antenna for Satellite and Terrestrial Links,” *IEEE Transactions on Vehicular Technology*, vol. 56, pp. 426-435, March 2007.

[35] K.M.Z. Shams and M. Ali, “Analyses of a Dipole Antenna Loaded by a Cylindrical Shell of Double Negative (DNG) Meta-Material,” *International Journal of Antennas and Propagation,* (online journal), 2007.

[36] R.H. Bhuiyan, R. Dougal, and M. Ali, “Proximity Coupled Interdigitated Sensors to Detect Insulation Damage in Power System Cables,” *IEEE Sensors Journal*, vol. 7, no. 12, pp. 1579-1586, December 2007.

[37] M. Ali, M. G. Douglas, A.T.M. Sayem, A. Faraone and C-K. Chou, “Threshold Power of Canonical Antennas for Inducing SAR at Compliance Limits in the 300-3000 MHz Frequency Range,” *IEEE Transactions on Electromagnetic Compatibility* vol. 49, pp. 143-152, January 2007.

[38] M. Ali and A. Tailor, “Broadband Coplanar Waveguide-Fed Slot Antenna for Wireless LAN and Microwave Imaging Applications,” *Microwave and Optical Technology Letters*, vol. 49, no. 4, pp. 846-852, April 2007.

[39] K.M.Z. Shams and M. Ali, “Wireless Power Transmission to a Buried Sensor in Concrete,” *IEEE Sensors Journal*, vol. 7, no. 12, pp. 1573-1577, December 2007.

[40] M. Z. Azad and M. Ali, “A New Class of Miniature Embedded Inverted-F Antennas (IFAs) for 2.4 GHz WLAN Application,” *IEEE Transactions on Antennas and Propagation,* vol. 54, no. 9, pp. 2585- 2592, Sept. 2006.

[41] M. Ali, G. Yang, and R. Dougal, "Miniature Circularly Polarized Rectenna with Reduced Out of Band Harmonics," *IEEE Antennas and Wireless Propagation Letters*, vol. 5, pp. 107-110, 2006.

[42] A.T.M. Sayem and M. Ali, “Characteristics of a Microstrip-Fed Miniature Printed Hilbert Slot Antenna,” *Progress in Electromagnetic Research, PIER,* 56, 1-18, 2006.

[43] K. M. Z. Shams, M. Ali, and H.-S. Hwang, “A Planar Inductively Coupled Bow-Tie Slot Antenna for WLAN Application,” *Journal of Electromagnetic Waves and Applications,* vol. 20, No. 7, pp. 861-871, 2006.

[44] K.M. Z. Shams and M. Ali, "Study and Design of a Capacitively Coupled Polymeric Internal Antenna,"*IEEE Transactions on Antennas and Propagat*ion, vol. 53, no. 3, pp. 985-993, March 2005.

[45] M. Z. Azad and M. Ali, "A Miniaturized Hilbert PIFA for Dual Band Mobile Wireless Applications," *IEEE Antennas and Wireless Propagation Letters,* vol. 4, pp. 59-62, 2005.

[46] M. F. Abedin and M. Ali, "Effects of EBG Reflection Phase Profiles on the Input Impedance and Bandwidth of Ultra-thin Directional Dipoles," *IEEE Transactions on Antennas and Propagat*ion, vol. 53, no. 11, pp. 3664-3672, Nov. 2005.

[47] M. F. Abedin and M. Ali, "Effects of a Smaller Unit Cell Planar EBG Structure on the Mutual Coupling of a Printed Dipole Array," *IEEE Antennas and Wireless Propagation Letters,* vol. 4, pp. 274-276, August 2005.

[48] M. Ali, G. Yang, and R. Dougal, "A New circularly polarized rectenna for Wireless Power Transmission and Data Communication," *IEEE Antennas and Wireless Propagation Letters,* vol. 4, pp. 205-208, July 2005.

[49] G. Yang, M. Ali, and R. Dougal, "A Wideband Circularly Polarized Microstrip Patch Antenna for Wireless LAN Applications," *Microwave and Optical Technology Letters,* vol. 45, no. 4, pp. 279-285, 20 May 2005.

[50] M. Ali, T. Sittironnarit, H. -S. Hwang, R. A. Sadler, and G. J. Hayes, "Wideband/DualBand Packaged Antenna for 5-6 GHz WLAN Application," *IEEE Transactions on Antennas and Propagat*ion, vol. 52, no. 2, pp. 610-615, Feb. 2004.

[51] M. Ali, R. Usaha, and Y. Hu "Study and Design of Broadband Coplanar Waveguide Fed Modified Folded Slot Antenna," *Radio Science*, Vol. 39, No. 4, pp. 1-8, Aug. 2004.

[52] G. Yang, M. Ali, and R. Dougal, "A Thin WideBand Microstrip Patch Antenna with Two Adjacent Slots," *Microwave and Optical Technology Letters*, vol. 41, issue 4, pp. 261-266, May 2004.

[53] M. Ali and R. Usaha, "A Broad-Band Folded Slot Antenna with a Semi-Circular Extension," *Microwave and Optical Technology Letters,* vol. 41, issue 1, pp. 32-37, April 2004.

[54] M. Ali, G. Yang, H.S. Hwang, and T. Sittironnarit, "Design and Analysis of an R-Shaped Dual-Band Planar Inverted-F Antenna for Vehicular Applications," *IEEE Transactions on Vehicular Technology*, vol. 53, no. 1, pp. 29-37, Jan. 2004.

[55] M. F. Abedin and M. Ali, "Modifying the Ground Plane and its Effect on Planar InvertedF Antennas (PIFAs) for Mobile Phone Handsets," *IEEE Antennas and Wireless Propagation Letters*, vol.2, issue 15, pp. 226-229, 2003.

[56] M. Ali, G.J. Hayes, H.-S. Hwang and R.A. Sadler, "Design of a Multi-Band Internal Antenna for Third Generation Mobile Phone Handsets," *IEEE Transactions on Antennas and Propagat*ion, vol. 51, no. 7, pp. 1452-1461, July 2003.

[57] K. V. Kumar, M. Ali, H.S. Hwang, and T. Sittironnarit, "Study of a Dual-Band Packaged Patch Antenna on a PC Card for 5-6 GHz Wireless LAN Applications," *Microwave and Optical Technology Letters,* vol. 37, pp. 423-428, June 2003.

[58] M. Ali, M. Okoniewski, and S.S. Stuchly, "Study of a printed meander antenna using the FDTD method," *Microwave and Optical Technology Letters,* vol. 37, pp. 440-444, June 2003.

[59] M. Ali and S.S. Stuchly, “An Experimental Study of Small Self-Resonant Antennas for Wireless Applications,” *Microwave and Optical Technology Letters*, vol. 35, no. 2, pp. 143-145, Oct. 2002.

[60] M. Ali and S.S. Stuchly, “A Novel Primary Feed Antenna for Plane Sheet Metallic Reflectors for Base Stations,” *Microwave and Optical Technology Letters,* Vol. 33, No. 6, pp. 407-408, June 20, 2002.

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[109] M. Okoniewski, M. Ali, M. Douglas, S. S. Stuchly and M. A. Stuchly, “Modeling of antennas for mobile communication”, *12th International Conference on Microwaves, Radar and Wireless Communications*, MIKON'98 Digest, Krakow, Poland, pp. 289-292, May 20-22, 1998.

[110] M. Ali, M. Okoniewski, M.A. Stuchly, and S.S. Stuchly, “A Dual-Frequency Strip-Sleeve Monopole Antenna for a Laptop Computer,” *IEEE Antennas and Propagation Society International Symposium Digest*, Vol. 2, 1998, pp. 794-797.

[111] M. Ali, S.S. Stuchly, and M. Okoniewski, “Characterization of Planar Printed Meander Antennas Using the Finite- Difference Time-Domain Technique,” *IEEE Antennas and Propagation Society International Symposium Digest*, Vol. 3, 1997, pp. 1546-1549.

[112] M. Ali, S.S. Stuchly, and M. Okoniewski, “Radiation Characteristics of Printed Meander Antennas,” *ANTEM, Symposium on Antenna Technology and Applied Electromagnetics*, Proc., Montreal, Canada, 1996, pp. 171-174.

[113] M. Ali and S.S. Stuchly, “A Meander-Line Bow-Tie Antenna,” *IEEE Antennas and Propagation Society International Symposium Digest*, Vol. 3, 1996, pp. 1566-1569.

[114] M. Ali and S.S. Stuchly, “Short Sinusoidal Antennas for Wireless Communications,” *Proceedings of the IEEE Pacific Rim Conference on Communications, Computers, and Signal Processing*, Victoria, Canada, 1995, pp. 542-545.

[115] M. Ali, S.S. Stuchly, and K. Caputa, “A Wide-Band Dual Meander-Sleeve Antenna,” *IEEE Antennas and Propagation Society International Symposium Digest*, Vol. 2, 1995, pp. 1124-1127.

[116] M. Ali, S.S. Stuchly, and K. Caputa, “Impedance Bandwidth of Bent Wire Antennas,” *International Union of Radio Science (URSI) Meeting Digest*, 1995, p. 72.

[117] M. Ali and S. S. Stuchly, “Resonance in short periodic bent wire antennas,” Progress in Electromagnetic Research Symposium Digest, Seattle, July 24-28, 1995, p. 574.

D. United States Patents

[1] M. Ali, R.H. Bhuiyan, R. Dougal, and M.N. Alam, *Non-Intrusive Cable Fault Detection and Methods,* US Patent Number: 9,103,864, August 2015.

[2] M. Ali, J.M. Caicedo, and X. Jin, *Wireless Power Transfer to Embedded Sensors*, US Patent Number: US 8,913,952, granted December 16, 2014.

[3] M. Ali, R.H. Bhuiyan, and R. Dougal, *Non-Intrusive Energy Harvesting Systems and Methods*, US Patent Number: US 8,564,298 B2, granted Oct. 22, 2013.

[4] M. Ali, "Inverted-F antenna for flip-style mobile terminals," US patent number: 6,885,880, granted April 26, 2005.

[5] R. Sadler, M. Ali, and G.J. Hayes, "Multi-frequency band inverted-F antennas with coupled branches and wireless communicators incorporating same," US patent number: 6,563,466, 13 May 2003.

[6] M. Ali, "Capacitively Coupled Plated Antenna," US patent number: 6,535,166, granted March 18, 2003.

[7] M. Ali, "Dual-Band Antenna Having Mirror Image Meandering Segments and Wireless Communicators Incorporating Same," US patent Number: 6,184,836, granted – 6 February 2001.

[8] R. Sadler, G. Hayes, and M. Ali, "Compact, broadband inverted-F antennas with conductive elements and wireless communicators incorporating same," US patent number: 6,218,992, granted -17 April 2001.

E. Un-refereed Publications

[1] M. Ali, "Design of a Wideband Microstrip Patch Antenna on PBG Type Substrates," Proceedings of the IEEE SouthEastCon 2002, Columbia, SC, pp. 48-51.

[2] T. Sittironnarit and M. Ali, "Analysis and Design of an Integrated Folded Microstrip Patch Antenna for Handheld Device Applications," Proceedings of the IEEE SouthEastCon 2002, Columbia, SC, pp. 255-258.

[3] M. Ali, "Antenna Design for Mobile Hand Held Devices," (book chapter) *Recent Research Development in Microwave Theory and Techniques, vol. 2*, Trans-world Research Network, 2002, pp. 261-278.

VII. Presentations and Seminars

A. Invited Presentations and Seminars

[1] "Conformal Reconfigurable Antennas for Air Vehicle Platforms," Structural Antenna Working Group Meeting (Organized by Boeing & AFRL), Dayton, Ohio, October 23, 2018.

[2] "High Performance Antenna Arrays in Portable and Wearable Wireless Applications," IEEE Chapter seminar at Washington State University, Richland, WA, August 1, 2018.

[3] "Wireless Power Transfer in Concrete using Near and Far Field Techniques," Pacific Northwest National Laboratory (PNNL), Richland, WA, July 31, 2018.

[4] "Overview of RF antennas in composite materials and structures," South Carolina Aerospace Symposium, Columbia, SC, August 24-25, 2016.

[5] Materials in "Broadband 3-D Reconfigurable Antenna on AlGaN/GaN on Sapphire," IEEE Antennas and Propagation Society International Symposium/URSI, Puerto Rico, June 2016.

[6] "Wireless Power Delivery under Concrete for Sensors," IEEE Antennas and Propagation Society International Symposium/URSI, Puerto Rico, June 2016.

[7] "Low cost pattern reconfigurable phased array antenna for body wearable wireless platforms,"2016 International Workshop on Antenna Technology, IEEE IWAT, Cocoa Beach, FL, Feb 29, March 2, 2016.

[8] "Novel Beam Steering Apertures and Waveforms for High Capacity Broadband Wireless Nodes" 2nd NSF EARS Workshop, Reston, VA, March 2016.

[9] "Wireless Power to Sensors Embedded in Concrete Structures," International Union of Radio Science (URSI) Meeting, Boulder, CO, January 6-9, 2016.

[10] "Compressed Foot-Print Parasitic Antenna Arrays and Metamaterials and Metasurfaces for Broadband Arrays," *University of Dayton*, April 16, 2014.

[11] "Antenna and Wireless Sensor Research at the USC Microwave Engineering Laboratory," *SPAWAR*, Charleston, SC, July 1, 2013.

[12] "Beam Steering Parasitic Antenna Arrays and Wireless Sensor Research at the University of South Carolina," *United International University*, Dhaka, December 23, 2012.

[13] "Beam Steering Parasitic Antenna Arrays and Wireless Sensor Research at the University of South Carolina," *Department of Electrical Engineering, University of South Florida*, Tampa, Sept 14, 2012.

[14] "Beam Steering Parasitic Antenna Arrays and Wireless Sensor Research at the University of South Carolina," *Motorola Solutions,* Plantation, FL, Sept 13, 2012.

[15] "Broadband Metamaterial and Antenna Research at the University of South Carolina," *Army Research Laboratory*, Adelphi, Maryland, August 14, 2012.

[16] "Structurally Embedded Antennas and Metamaterials in Communication and Sensing, *Army Research Office*, Durham, NC, October 12, 2011.

[17] "Metamaterials and Metasurfaces for Ultra-Thin Flexible Directional Apertures," *NSF Workshop on Micro, Nano and Bio Systems*, March 30-31, 2012. (poster)

[18] "Integrated Antennas, Sensors, and Metamaterials," *Sensors Directorate, Air Force Research Laboratory, Wright Patterson Air Force Base*, Ohio, October 19, 2011.

[19] "Conformal Antennas for Unmanned Aircraft Systems," *Sensors Directorate, Air Force Research Laboratory, Wright Patterson Air Force Base*, Ohio, June 28, 2011.

[20] "Integrated Antennas, Engineered Materials and Wireless Sensors," *University of Utah*, 20 April 2009.

[21] "Determining Maximum Allowable Emitted Power Level from Low-Power Transmitters for SAR Compliance," *Mobile Manufacturer's Forum and the European Bioelectromagnetics Conference Participants*, Bordeaux, France, April 10, 2007.

[22] "Educational and Research Facilities at the Department of Electrical Engineering at the University of South Carolina," *Bangladesh University of Engineering and Technology, Dhaka*, June 27, 2007.

[23] "A Low Profile Dipole Antenna Backed by a Planar EBG Structure," *IEEE International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials,* White Plains, NY, 6-8 March 2006.

[24] "Study and design of a multi-functional stacked microstrip patch antenna," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Monterey, CA, June 2004.

[25] "Multi-Band Antennas and Engineered Materials for Mobile Wireless Applications," *Motorola Corporate EME Research Laboratory*, Plantation, FL, August 12, 2004.

[26] "Low-Power SAR Exclusion," *Motorola Corporate EME Research Laboratory*, Plantation, FL, August 12, 2004.

[27] "Multi-Band Antennas and Engineered Materials in Wireless Applications," *University of South Carolina*, March 5, 2004.

[28] "Wideband (5-6 GHz WLAN Band) Circularly Polarized Patch Antenna for Wireless Power Sensors," *IEEE Antennas and Propagation Society International Symposium*, Columbus, Ohio, June 2003.

[29] "Designing Ultra-Thin Planar Inverted-F Antennas," *IEEE Antennas and Propagation Society International Symposium*, Columbus, Ohio, June 2003.

[30] "Miniaturized Multi-functional Packaged Antennas and Circuits for Wireless Application," *University of South Carolina*, April 4, 2003.

[31] "Undergraduate Microfabrication Lab for Wireless and Power Devices," *University of South Carolina*, 21 March 2003, USC.

[32] "Self-Resonant Bent Antennas in Wireless Communications," *University of South Carolina*, June 2001.

[33] "Self-Resonant Bent Antennas in Wireless Communications," *Florida International University*, July 2001.

[34] "Antenna Design and Analysis for Mobile Handheld Terminals," *Motorola Inc.,* Bothell, Washington, Fall 2000.

[35] "Antenna Design for Wireless Personal Communications," *Lucent Technologies*, NJ, Summer 1997.

B. Papers Presented at Professional Conferences

[1] "Fabric based beam steering wearable antenna array," 12th European Conference on Antennas and Propagation, April 2018, London, UK.

[2] "High-Gain Series-Fed Phased Array Antenna for Wearable Wireless Applications," 12th European Conference on Antennas and Propagation, April 2018, London, UK.

[3] "A Broadband High-Gain Aperture Coupled Patch Array for Communication and Radar Applications," *IEEE Antennas and Propagation Society International Symposium*, San Diego, July 2017.

[4] "Effect of bias traces and wires on a MEMS reconfigurable pixelated patch antenna," *IEEE Antennas and Propagation Society International Symposium*, Puerto Rico, June 2016.

[5] "VHF antenna for airfoil structural integration," *IEEE Antennas and Propagation Society International Symposium*, Puerto Rico, June 2016. Poster.

[6] "A Thin Switched Beam Parasitic Antenna Array on Planar EBG for 2.4 GHz Wireless Application," *IEEE Antennas and Propagation Society International Symposium*, Puerto Rico, June 2016. Poster.

[7] "Non-Contact Surface Wave Sensing of Wire Fault Precursors," *IEEE Antennas and Propagation Society International Symposium*, Vancouver, BC, July 2015.

[8] "Superstrate Configurations for a MEMS Reconfigurable Pixelated Patch Antenna for CLAS," *IEEE Antennas and Propagation Society International Symposium*, Vancouver, BC, July 2015. Poster.

[9] "Conformal Direct Written Antenna on Structural Composites," *IEEE Antennas and Propagation Society International Symposium*, Vancouver, BC, July 2015.

[10] "A High-Gain Beam Steering Fabric-Based Array for Body-worn Wireless Applications," *IEEE Antennas and Propagation Society International Symposium*, Vancouver, BC, July 2015. Poster

[11] "Broadband Directional Antenna on an EBG Structure for Body-Centric Wireless Communication," *Applied Computational Electromagnetics Society (ACES) Conference*, Williamsburg, VA, March 2015.

[12] "A MEMS Reconfigurable Pixel Microstrip Patch Antenna for Conformal Load Bearing Antenna Structures (CLAS) Concept" *IEEE Antennas and Propagation Society International Symposium*, Memphis, TN, July 2014.

[13] "Aperture Coupled MEMS Reconfigurable Pixel Patch Antenna for Conformal Load Bearing Antenna Structures (CLAS)," *IEEE Antennas and Propagation Society International Symposium*, Memphis, TN, July 2014.

[14] "A Pixelated Pattern Reconfigurable Yagi-Uda Array for Conformal Loadbearing Antenna Structure (CLAS)," *IEEE Antennas and Propagation Society International Symposium*, Memphis, TN, July 2014.

[15] "Wireless Power Transfer to Closely Coupled Loop Antennas Embedded in Concrete for Sensing," *Applied Computational Electromagnetics Society (ACES) Conference*, Jacksonville, FL, March 2014.

[16] "Pattern Reconfigurable 5.5 GHz Collinear Antenna Array for MIMO Application," *Applied Computational Electromagnetics Society (ACES) Conference*, Jacksonville, FL, March 2014.

[17] "A Broadband VHF-UHF Yagi-Uda End-Fire Array," *IEEE Antennas and Propagation Society International Symposium*, Orlando, FL, July 2013.

[18] "A Varactor Controlled 900 MHz Body-Wearable Antenna Array," *IEEE Antennas and Propagation Society International Symposium*, Orlando, FL, July 2013 (URSI).

[19] "Wireless Interdigitated Near-Field Sensors for Concrete Moisture Content Measurement," *IEEE Antennas and Propagation Society International Symposium*, Orlando, FL, July 2013 (URSI).

[20] "Body-Wearable Beam Steering Antenna Array for 5.2 GHz WLAN Applications," International Conference on Electrical and Computer Engineering, Dhaka, Bangladesh, Dec. 2012.

[21] "Beam Steering Body-Worn Smart Antenna Arrays," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Chicago, July 2012.

[22] "A Near-Isotropic Pattern 3-D Loop Antenna for Networked Sensors," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Chicago, July 2012.

[23] "Near-Field Antenna Systems for Wireless Power Transfer to Embedded Sensors," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Chicago, July 2012. (Poster)

[24] "Wideband UHF Metamaterial Antenna," *IEEE Antennas and Propagation Society*

International Symposium and URSI/USNC Meeting, Chicago, July 2012. (Poster)

[25] "In-Situ Surface Wave Launchers for Power Line Fault Detection," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Chicago, July 2012.

[26] "A 24 GHz Shaped Geometry Planar Array Antenna," *International Union of Radio Science (URSI) Meeting*, Spokane, WA, July 2011.

[27] "A Novel Wearable Antenna Array for 2.45 GHz WLAN Application," *IEEE Antennas and Propagation Society International Symposium*, Spokane, WA, July 2011.

[28] "Temperature Rise in an Anatomical Human Head Model Due to 2.45 and 3.7 GHz Inverted-F Antennas," *IEEE Antennas and Propagation Society International Symposium*, Spokane, WA, July 2011.

[29] "Novel Low Cost Soil Moisture Sensors using Fringing Electric Fields for Agricultural and Forestry Applications," *International Union of Radio Science (URSI) Meeting*, Spokane, WA, July 2011.

[30] "A Double Meander PIFA with a Parasitic Metal Box for Wideband 4G Mobile Phones," *IEEE Antennas and Propagation Society International Symposium*, Spokane, WA, July 2011.

[31] "SAR Induced by Dipole Antennas to Determine Low Power Thresholds for Wireless Transmitters at Distances of 25 – 200 mm from the User," *Bioelectromagentics Society Conference*, Davos, Switzerland, June 2009.

[32] "Computed SAR and Temperature Rise in an Anatomical Head Model by a 900 MHz Dipole Antenna," *Bioelectromagentics Society Conference*, Davos, Switzerland, June 2009. (poster).

[33] "SAR AND TEMPERATURE RISE IN DIFFERENT HEAD MODELS DUE TO THE ELECTROMAGNETIC RADIATION FROM CANONICAL ANTENNAS," *Bioelectromagentics Society Conference*, Davos, Switzerland, June 2009. (poster)

[34] "A New Crossed Staircase Dipole Antenna for 915 MHz RFID Application," IEEE AP-S International Symposium, San Diego, CA 2008.

[35] "An Equivalent Circuit Model of a Corrugated Metamaterial Structure and its Applications," *International Union of Radio Science (URSI)*, San Diego, CA 2008.

[36] "SAR INDUCED BY MONOPOLE AND PLANAR ANTENNAS TO DETERMINE A THRESHOLD POWER LEVEL," *Bioelectromagnetics Society 29th Annual Meeting*, Kanazawa, Japan, June 11-15, 2007.

[37] "Proximity Coupled Wireless Sensors for Power System Monitoring" *Electric Ship Research and Development Consortium*, May 7, 2007, Boston. (Poster presentation)

[38] "Bandwidth, Efficiency and SAR of Canonical Antennas," *Bioelectromagnetics Society 28th Annual Meeting*, Cancun, Mexico, June 11-15, 2006.

[39] "A Miniaturized Implantable Antenna for GPS Application," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Albuquerque, NM, July 2006.

[40] "A Miniature Packaged Rectenna for Wireless Power Transmission and Data Telemetry," *IEEE International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials,* White Plains, NY, 6-8 March 2006.

[41] "The Input Impedance of a Dipole Antenna Loaded by a Cylindical Shell of Double Negative (DNG) Meta-Material," *IEEE AP-S International Symposium and Union of Radio Science (URSI) Meeting*, Washington, DC, July 2005.

[42] "Application of EBG Substrates to Design Ultra-Thin Wideband Directional Dipoles," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Monterey, CA, June 2004.

[43] "A Miniature Hilbert Planar Inverted-F Antenna (PIFA) for Dual-Band Mobile Phone Applications," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting, Monterey*, CA, June 2004.

[44] "A Capacitively Coupled Polymeric Internal Antenna," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Monterey, CA, June 2004.

[45] "A Miniature Hilbert Slot Antenna for Dual-Band Wireless Application," *IEEE Antennas and Propagation Society International Symposium and URSI/USNC Meeting*, Monterey, CA, June 2004.

[46] "Design of broadband modified folded slot antennas for C band wireless applications," *IEEE AP-S Topical Conference on Wireless Communication Technology and NSF Grantees Workshop*, Honolulu, October 15-17, 2003.

[47] "Reconfigurable Stacked patch antenna for satellite and terrestrial applications," *IEEE AP-S Topical Conference on Wireless Communication Technology and NSF Grantees Workshop*, Honolulu, October 15-17, 2003.

[48] "Wideband CPW-Fed Slot Antennas on Finite Ground Planes," *International Union of Radio Science Meeting*, June 2003, Columbus, Ohio.

[49] "Wideband Patch Antenna for 5-6 GHz WLAN Applications," *IEEE Antennas and Propagation Society International Symposium*, Columbus, Ohio, June 2003.

[50] "A Triple-Band Internal Antenna for Mobile Hand-held Terminals," *IEEE Antennas and Propagation Society International Symposium*, San Antonio, 2002.

[51] "A Dual-Band Vehicular Planar Inverted-F Antenna for Ultra High Frequency (UHF) Applications," *IEEE Semiannual Vehicular Technology Conference in Birmingham*, AL, May 2002.

[52] "Design of a Wideband Microstrip Patch Antenna on PBG Type Substrates," *IEEE SoutheastCon2002*, Columbia, SC.

[53] "Analysis of Integrated Inverted-F Antennas for Bluetooth Applications," *IEEE Antennas and Propagation Conference for Wireless Communication*, Waltham, MA, Nov. 2000.

[54] "Characterization of Planar Printed Meander Antennas Using the Finite- Difference Time-Domain Technique," *IEEE Antennas and Propagation Society International Symposium,* Montreal, Canada, 1997.

[55] "Radiation Characteristics of Printed Meander Antennas," *ANTEM, Symposium on Antenna Technology and Applied Electromagnetics*, Montreal, Canada, 1996.

[56] "Short Sinusoidal Antennas for Wireless Communications," *IEEE PacificRim Conference on Communications, Computers, and Signal Processing*, 1995, Victoria, Canada.

[57] "Resonance in short periodic bent wire antennas," *Progress in Electromagnetic Research Symposium, Seattle*, July 24-28, 1995.

VIII. Research Supervision

A. Post-doctoral Scholars

[1] Nazmul Alam, *Efficiency Characterization of Electrically Small Embedded Antennas*, 2014
[2] Xiaohua Jin, *Wireless Embedded Sensors for Infrastructure Health Monitoring*, 2012.
[3] Rashed H. Bhuiyan, *Wireless Embedded Sensors for Infrastructure Health Monitoring*, 2011.

B. Ph.D. Students Graduated

[1] David Zeppettella[9], *Multifunctional Radio Frequency Composite Structures*, 2018.
[2] Michael Wright[8], *Structurally Integrated Reconfigurable Wideband Array for Conformal Applications*, 2018.
[3] Nowrin Chamok[1], *High Gain Pattern Reconfigurable Antenna Arrays for Portable and Body-Centric Wireless Applications*, 2016.
[4] Md. Nazmul Alam[2], *Applications of Electromagnetic Principles in the Design and Development of Proximity Wireless Sensors,* 2014.
[5] Md. Rashidul Islam[3], *Beam Steering Parasitic Antenna Arrays for Portable and Wearable Wireless Applications*, 2012.
[6] Xiaohua Jin, *Embedded Antennas in Concrete for Application in Wireless Sensors*, 2011.
[7] Rashed H. Bhuiyan[4] *Non-intrusive Wireless Sensors for Power System Applications*, 2010.
[8] M. Ziaul Azad[5], *Antenna Design using Space-Filling Curves and Electromagnetic Bandgap Structures*, 2008.
[9] Abu T.M. Sayem[4], *Designing Electrically Small Antennas and the Effects of their Radiation on Humans Pertaining to Low Power Transmitter*, 2007.
[10] Khan M.Z. Shams[7], *Novel Embedded Antennas and Engineered Materials in Wireless Communications and Sensing*, 2007.
[11] Guangli Yang[6], *Conformal Multi-Functional Antennas and Rectifying Circuits for Wireless Communications and Microwave Power Beaming*, 2005.
[12] Faisal Abedin[3], *Miniaturization and Gain Enhancement of WideBand Low-Profile Antennas on Engineered Structures*, 2005.

Last known position
1. Boston Scientific, LA, CA
2. NuCurrent, Chicago, IL
3. Motorola Mobility (Lenovo), Libertyville, IL
4. Garmin International, Overland Park, KS
5. Amazon, CA
6. Professor at Shanghai University, China
7. Google, CA
8. Ball Aerospace, Colorado
9. Air Force Research Lab, Wright Patterson Air Force Base, OH

C. M.S. Students Graduated

[1] Paul Czeresko III, Novel Wideband EBG Structures for Isolation Improvement between Cosite Antennas, 2017[1].
[2] Dhruva Poduval[2], Wideband Low Side Lobe Aperture Coupled Patch Phased Array Antennas, 2017.
[3] Nicholas A. Bishop[3], *Ultrawideband (UWB) and Reconfigurable Antennas –New Concepts for Conformal Load Bearing Antenna Structures (CLAS)*, 2013.
[4] Hamad Aldossary, *Design and Analysis of an Electronically Steerable Microstrip Patchand a Novel Coplanar Waveguide (CPW) Fed Slot Antenna Array*, 2013.
[5] Md. Anas B. Mazady, *Electromagnetic Exposure in a Phantom in the Near and Far Fields of Wire and Planar Antennas*, 2010.
[6] Yanwei Hu[4], *Low Profile Ultra-Wideband (UWB) Slot Antenna with Coplanar Waveguide (CPW) Feed*, 2005.
[7] Vijay K. Kunda[5], *Study and Design of a Reconfigurable Stacked Microstrip Patch Antenna for Satellite and Terrestrial Applications*, 2004.
[8] Rachan Usaha, *Analysis and Design of Broadband CPW-Fed Slot Antennas for C-Band Wireless Applications*, 2003.
[9] Tuangsit Sittironnarit, *Analysis and Design of a Multi-Band Embedded Microstrip Antenna for Wireless LAN Application between 5-6 GHz*, 2002.

Last known position

1. Cobham, PA
2. Harris Corporation, Melbourne, FL
3. Apple, CA
4. Motorola Mobility (Lenovo), IL
5. Intel, OR

D. Current Graduate Students

[1] Michael Brown, Electromagnetic heating of nanoparticles in a liquid, (Started 2015). **(Ph.D student)**
[2] Ankit Patel (M.S. Student)
[3] Nazmul Al-Imran (PhD Student)
[4] Ahmed Arman (PhD Student)
[5] Dillon Lindsay (MS student)
[6] Ahmed Hamdy AbdelGawaad, (PhD student)

E. Current Undergraduate Students

None

F. Undergraduate Students Supervised

[1] Brown Mattox, Summer 2016, Fall 2017 (NSF REU)
[2] Paul Czeresko III, Summer 2015 (NSF REU)
[3] Deidra Walls, Summer 2015 (NSF REU)
[4] Jacob Morgan, Summer 2014 (NSF REU)
[5] Deidra Walls, Summer 2014
[6] Jacob Morgan, Summer and Fall 2013 (NSF REU).
[7] Michael Brown, Summer 2013, (NSF REU)
[8] Daryl Hill, Sumer 2013
[9] Mark Neal, Conformal Antennas, Fall 2012
[10] Nicholas A. Bishop, 2011 (AFOSR, AFRL)
[11] Sadia Khan, 2007, (NSF REU)
[12] Ashit Tailor, 2005, (NSF REU)
[13] Ifeakachuki S. Ekpenuma, 2003

G. High School Student Supervision (Summer)

[1] Archie Adams, *Multi-Element Diversity Antenna System for High Capacity Wireless Communications*, 2006.
[2] Seth Crouch, *Miniature Embedded Microstrip Patch Antennas for Mobile Handheld Device GPS Application*, 2005.
[3] Reginald Coleman, *A Miniaturized Fractal Embedded Antenna for Wireless Handheld Device Application*, 2004.
[4] William P. Cram, *Dual-Band Microstrip Patch Antennas for Wireless Applications*, Intel and Siemens Westinghouse Science Competition Semi-Finalist, 2002.

IX. Professional Service Activities

- Associate Editor, IEEE Antennas and Wireless Propagation Letters Journal (January 2008 - December 2013)
- Technical Program Co-Chair, IEEE Antennas and Propagation Society International Symposium, Charleston, SC (January 2008 – July 2009)
  The conference was in June 2009. I along with Dr. Gianluca Lazzi handled manuscripts, communicated with reviewers, Technical Program Committee (TPC) members, collected reviews, led TPC members in session creation, communicated with attendees, and executed the technical program.
- Special session Organizer on Reconfigurable Antennas (Feb 2016-March 2016)
  Orgaznied a special session on reconfigurable antennas with Prof. Jennifer Bernhard for the 2016 International Workshop on Antenna Technology: Small Antennas, Innovative Structures, and Applications, IEEE IWAT, Cocoa Beach, FL, Feb 29-March 2, 2016.
- Editorial Board Member, International Journal of RF and Microwave Computer-Aided Engineering, RFMiCAE, Since November 2015.
- Editorial Board Member, International Journal of Antennas and Propagation, since 2009.

Roles and Activities in Major Professional Conferences

- Member of the Technical Program Committee, IEEE Antennas and Propagation Society International Symposium, Boston, (**2012-2019, 2005-2010**).
- Member of the Technical Program Committee, 10th European Conference on Antennas and Propagation, Paris, France, 2017-2019.
- Member of the Technical Program Committee on International Workshop on Antenna Technology: Small Antennas, Innovative Structures, and Applications IEEE IWAT, Greece, 2017.
- Member of the Reviewing Sub-Committee, Asia Pacific Microwave Conference, 2016
- Member of the Technical Program Committee, 2016 International Workshop on Antenna Technology: Small Antennas, Innovative Structures, and Applications, IEEE IWAT, Cocoa Beach, FL, Feb 29-March 2, 2016.
- Member of the Technical Program Committee, 9th European Conference on Antennas and Propagation, Lisbon, Portugal, April 2015.
- Member, Technical Program Committee, IEEE Smart Grid Conference, 2011.
- Member, Technical Program Committee, IEEE Smart Grid Conference, 2010.
- Special Session Organizer (with Parveen Wahid) entitled Advances on Platform Integrated (Embedded) Antennas, IEEE Antennas and Propagation Society International Symposium, Washington, DC, 2005.
- Session Chair, IEEE Antennas and Propagation Society International Symposium (2003-2006, 2008-2009, 2011-2017)
- Judge, Student paper competition, IEEE Antennas and Propagation Society International Symposium, 2017.
- Session Chair, Applied Computational Electromagnetics Society Conference, Williamsburg, VA, 2015.
- Session Chair, IEEE International Workshop on Antenna Technology, White Plains, NY, 2003.
  Session Chair, IEEE Semiannual Vehicular Technology Conference, Birmingham, AL, 2002.

Paper Reviewing Activities (Journals)

IEEE Transactions on Antennas and Propagation, IEEE Antennas and Wireless propagation Letters, IEEE Transactions on Microwave Theory and Techniques, IEEE Transaction on Instrumentation and Measurements, IEEE Transactions on Electromagnetic Compatibility, IEEE Transactions on Vehicular Technology, IEEE Microwave and Wireless Component Letters, IEEE Sensors Journal, IEEE Antennas and Propagation Magazine, Journal of Electromagnetic Waves and Applications, International J. of RF/Microwave and Computer Aided Engineering

Invited Grant Proposal Review/Panel Roles and Activities

1.	Proposal reviewer & panelist, NSF Electrical, Communication, Circuits and Systems (ECCS) Proposals	May 2018
2.	Proposal reviewer & panelist, NSF ECCS Proposals	Apr. 2018
3.	Proposal reviewer & panelist, NSF Innovative Technology Experiences for Students and Teachers (ITEST) Proposals	Oct. 2017
4.	Proposal reviewer & panelist, NSF ECCS Proposals	Feb. 2017
5.	Proposal reviewer & panelist, NSF ITEST Proposals	Sept. 2016
6.	Proposal reviewer & panelist, - Research Competitiveness Program at the American Association for the Advancement of Science (AAAS)	March – April 2015
7.	Proposal reviewer & panelist, - National Science Foundation (NSF) Enhancing Access to the Radio Spectrum (EARS)	June 2014
8.	Proposal reviewer & panelist, - Research Competitiveness Program at the American Association for the Advancement of Science (AAAS)	October – November 2013
9.	Proposal reviewer & panelist, - National Science Foundation (NSF) Enhancing Access to the Radio Spectrum (EARS)	August 2013
10.	Proposal Reviewer - US Army Research Office	2012
11.	Proposal Reviewer - Canadian National Science and Engineering Research Council (NSERC)	2011
12.	Proposal reviewer & panelist, - National Science Foundation (NSF) Integrated Hybrid and Complex Systems (IHCS)	2010 (invited but declined)
13.	Proposal Reviewer - Canadian National Science and Engineering Research Council (NSERC)	2009
14.	Proposal reviewer & panelist, - National Science Foundation (NSF) Major Research Instrumentation (MRI)	2009
15.	Proposal reviewer - US Army Research Office	2008
16.	Proposal reviewer & panelist - National Institute of Health (NIH)	2008
17.	Proposal reviewer - Oak Ridge Associated Universities	2006
18.	Proposal reviewer - USC Research and Productive Scholarship	2006
19.	Proposal reviewer & panelist, - National Science Foundation (NSF)	2005
20.	Proposal reviewer & panelist, - National Science Foundation (NSF)	2005
21.	Proposal reviewer & panelist - National Science Foundation (NSF) Faculty Early Career	2004
22.	Proposal reviewer – South Carolina EPSCoR/SBIR	2004

Other Service Activities

A. Departmental and University Level Service

Dates	Duties
May 2017 – Present	**Chair, EE Dept. Tenure and Promotion Committee**
August 2014 – July 2017	Chair, Departmental Faculty Search Committee
August 2006-July 2008	Chair, ABET Committee - developed new methods for a thru k outcome assessments including criteria and rubrics; attended two ABET workshops; one in Tampa, FL in 2006 and another one in Phoenix, AZ in 2007.
June 2012- June 2013	Graduate Director - responsible for graduate student admission and all administrative duties associated with the graduate program
June 2008-June 2009	Graduate Director - responsible for graduate student admission and all administrative duties associated with the graduate program
Jan 2016-Present	Member, T&P Committee CEE, USC
August 2014 – May 2017	**Member, University Committee on Tenure and Promotion**
Feb. 2016 – Mar. 2016	Member, Dean's Associate Dean for Diversity hire
Dec. 2016 – Feb. 2017	Member, Dean's Associate Dean for Strategic Initiatives hire
2011-2012	Provost's Senior Faculty Hiring Initiative – coauthored a competitive proposal to the provost to hire a senior faculty member in Radio Frequency Microwave area; proposal won
Feb. 2011- June 2011	Member, College Faculty Awards Committee
Jan. 2012-July 2012	Member, Departmental Chair Search Committee
August 2013 - 2016	Faculty Advisor, Bangladesh Student Association
August 2010-July 2011	Member, University Level Graduate Council Awards and Scholarship Committee – reviewed scholarship application packages from students, deliberated in a panel and made decisions
April 2010	Judge, Discovery Day student research competition
April 2009	Judge, Discovery Day student research competition
Aug. 2010 – Aug. 2012	Chair, Department Publicity Committee – Departmental
	research flyer development, all faculty 3 slide research summary
Aug. 2001 – July 2012	Member, Graduate Course Curriculum Committee – Course, curriculum development, graduate program planning
August 2002-July 2006	Member, Undergraduate Recruitment Committee - took attempts to attract promising students to our undergraduate programs. One specific example is outreach to high school students.

Jan. 2004-July 2006	**Chair, USC Showcase Presentation**– organized the department's participation at the USC (university of South Carolina) showcase every year from 2004 to 2006. This is a one day event which is open to the public where the department shows its different teaching and research programs
Aug. 2001- July 2012	Member, Undergraduate Course and Curriculum Committee
August 2003-July 2004	Faculty Senator – Attended faculty senate meetings